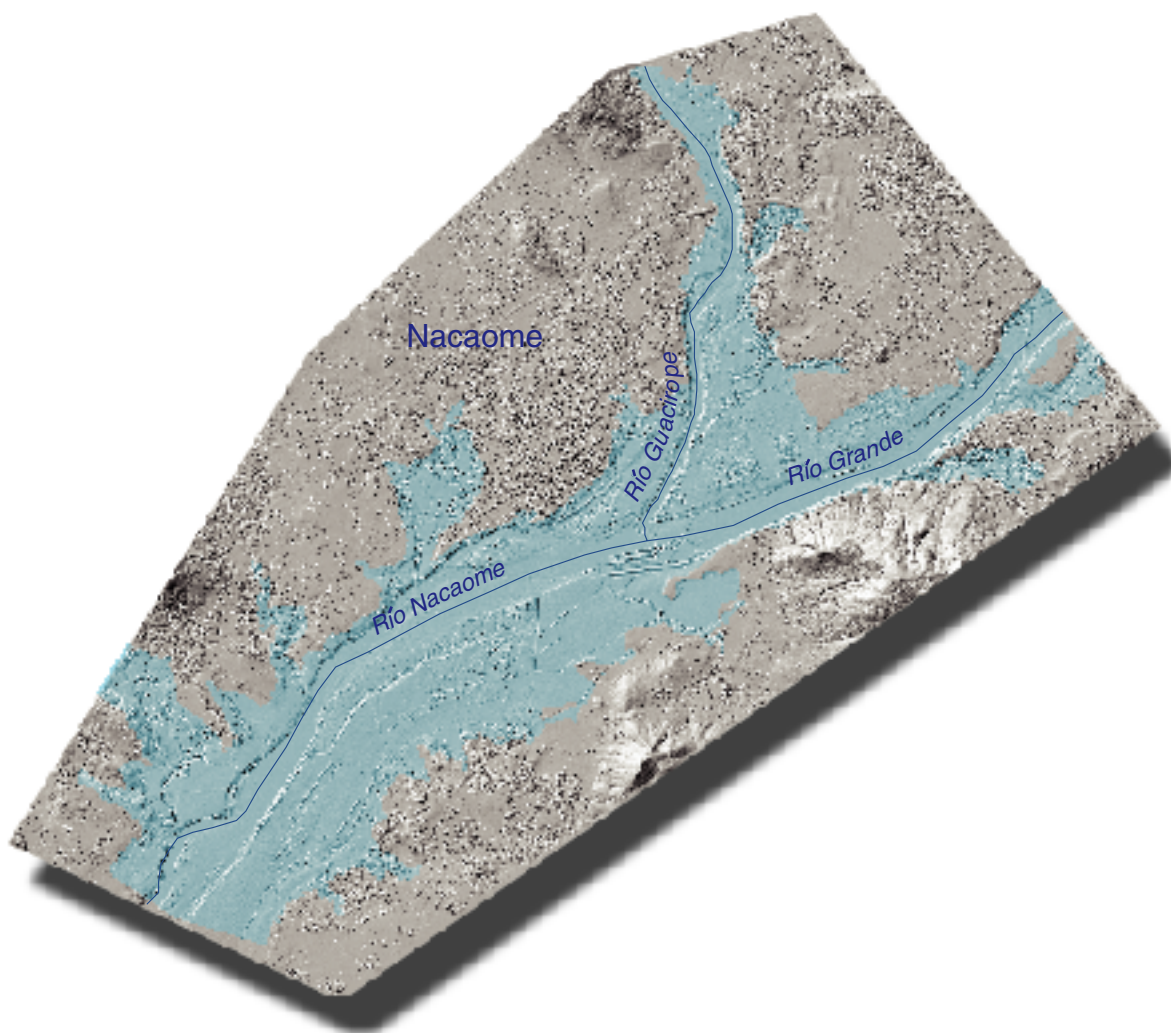**USGS**
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Fifty-Year Flood-Inundation Maps for Nacaome, Honduras

U.S. Geological Survey Open-File Report 02-256

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Fifty-Year Flood-Inundation Maps for Nacaome, Honduras

By David L. Kresch, Mark C. Mastin, and Theresa D. Olsen

U.S. GEOLOGICAL SURVEY

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Tacoma, Washington
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U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

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CONVERSION FACTORS

Multiply	By	To obtain
cubic meter per second (m³/s)	35.31	cubic foot per second
kilometer (km)	0.6214	mile
meter (m)	3.281	foot
millimeter (mm)	0.03937	inch
square kilometer (km²)	0.3861	square mile

VERTICAL DATUM

Elevation: In this report "elevation" refers to the height, in meters, above the ellipsoid defined by the World Geodetic System of 1984 (WGS 84).

Fifty-Year Flood-Inundation Maps for Nacaome, Honduras

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ABSTRACT

After the devastating floods caused by Hurricane Mitch in 1998, maps of the areas and depths of 50-year-flood inundation at 15 municipalities in Honduras were prepared as a tool for agencies involved in reconstruction and planning. This report, which is one in a series of 15, presents maps of areas in the municipality of Nacaome that would be inundated by 50-year floods on Río Nacaome, Río Grande, and Río Guacirope. Geographic Information System (GIS) coverages of the flood inundation are available on a computer in the municipality of Nacaome as part of the Municipal GIS project and on the Internet at the Flood Hazard Mapping Web page (http://mitchnts1.cr.usgs.gov/projects/floodhazard.html). These coverages allow users to view the flood inundation in much more detail than is possible using the maps in this report.

Water-surface elevations for 50-year-floods on Río Nacaome, Río Grande, and Río Guacirope at Nacaome were computed using HEC-RAS, a one-dimensional, steady-flow, step-backwater computer program. The channel and floodplain cross sections used in HEC-RAS were developed from an airborne light-detection-and-ranging (LIDAR) topographic survey of the area and ground surveys at two bridges.

The estimated 50-year-flood discharge for Río Nacaome at Nacaome, 5,040 cubic meters per second, was computed as the drainage-area-adjusted weighted average of two independently estimated 50-year-flood discharges for the gaging station Río Nacaome en Las Mercedes, located about 13 kilometers upstream from Nacaome. One of the discharges, 4,549 cubic meters per second, was estimated from a frequency analysis of the 16 years of peak-discharge record for the gage, and the other, 1,922 cubic meters per second, was estimated from a regression equation that relates the 50-year-flood discharge to drainage area and mean annual precipitation. The weighted-average of the two discharges is 3,770 cubic meters per second.

The 50-year-flood discharges for Río Grande, 3,890 cubic meters per second, and Río Guacirope, 1,080 cubic meters per second, were also computed by adjusting the weighted-average 50-year-flood discharge for the Río Nacaome en Las Mercedes gaging station for the difference in drainage areas between the gage and these river reaches.

INTRODUCTION

In late October 1998, Hurricane Mitch struck the mainland of Honduras, triggering destructive landslides, flooding, and other associated disasters that overwhelmed the country's resources and ability to quickly rebuild itself. The hurricane produced more than 450 millimeters (mm) of rain in 24 hours in parts of Honduras and caused significant flooding along most rivers in the country. A hurricane of this intensity is a rare event, and Hurricane Mitch is listed as the most deadly hurricane in the Western Hemisphere since the "Great Hurricane" of 1780. However, other destructive hurricanes have hit Honduras in recent history. For example, Hurricane Fifi hit Honduras in September 1974, causing 8,000 deaths (Rappaport and Fernandez-Partagas, 1997).

As part of a relief effort in Central America, the U.S. Agency for International Development (USAID), with help from the U.S. Geological Survey (USGS), developed a program to aid Central America in rebuilding itself. A top priority identified by USAID was the need for reliable flood-hazard maps of Honduras to help plan the rebuilding of housing and infrastructure. The Water Resources Division of the USGS in Washington State, in coordination with the International Water Resources Branch of the USGS, was given the task to develop flood-hazard maps for 15 municipalities in Honduras: Catacamas, Choloma, Choluteca, Comayagua, El Progreso, Juticalpa, La Ceiba, La Lima, Nacaome, Olanchito, Santa Rosa de Aguán, Siguatepeque, Sonaguera, Tegucigalpa, and Tocoa. This report presents and describes the determination of the area and depth of inundation in the municipality of Nacaome that would be caused by 50-year floods on Río Nacaome, Río Grande, and Río Guacirope.

The 50-year flood was used as the target flood in this study because discussions with the USAID and the Honduran Public Works and Transportation Ministry indicated that it was the most common design flood used by planners and engineers working in Honduras. The 50-year flood is one that has a 2-percent chance of being equaled or exceeded in any one year and on average would be equaled or exceeded once every 50 years.

Purpose, Scope, and Methods

This report provides (1) results and summary of the hydrologic analyses to estimate the 50-year-flood discharges used as input to the hydraulic model, (2) results of the hydraulic analysis to estimate the water-surface elevations of the 50-year-flood discharges at cross sections along the stream profiles, and (3) 50-year-flood inundation maps for Nacaome showing area and depth of inundation.

The analytical methods used to estimate the 50-year-flood discharges, to calculate the water-surface elevations, and to create the flood-inundation maps are described in a companion report by Mastin (2002). Water-surface elevations along Río Nacaome, Río Grande, and Río Guacirope were calculated using HEC-RAS, a one-dimensional, steady-flow, step-backwater computer model; and maps of the area and depths of inundation were generated from the water-surface elevations and topographic information.

The channel and floodplain cross sections used in HEC-RAS were developed from an airborne light-detection-and-ranging (LIDAR) topographic survey of Nacaome and ground surveys at two bridges. Because of the high cost of obtaining the LIDAR elevation data, the extent of mapping was limited to areas of high population density where flooding is expected to cause the worst damage. The findings in this report are based on the conditions of the river channels and floodplains on March 3-4, 2000, when the LIDAR data were collected, and March 16, 2000, and January 10, 2001, when the bridges were surveyed.

Acknowledgments

DESCRIPTION OF STUDY AREA

The study area includes the channel and floodplains of Río Nacaome, Río Grande, and Río Guacirope (figure 1). Río Grande, which flows from the northeast, and Río Guacirope, which flows from the north, join near the southeast border of Nacaome to form Río Nacaome. The study-area reach of Río Nacaome extends from the confluence of Río Grande and Río Guacirope to about 3 kilometers (km) downstream. The reaches of Río Grande and Río Guacirope extend from their confluence to about 3 and 2.5 km upstream, respectively.

The headwaters of Río Grande and Río Guacirope originate from several mountains in south-central Honduras. The streambeds of Río Nacaome, Río Grande, and Río Guacirope consist mainly of silt, sand, and gravel covered in most places by an armoring of cobbles. The amount of vegetation covering the main channel banks and floodplains varies considerably. The banks and floodplains are covered with medium to dense vegetation in some areas, but are nearly bare or covered by only light vegetation in other areas.
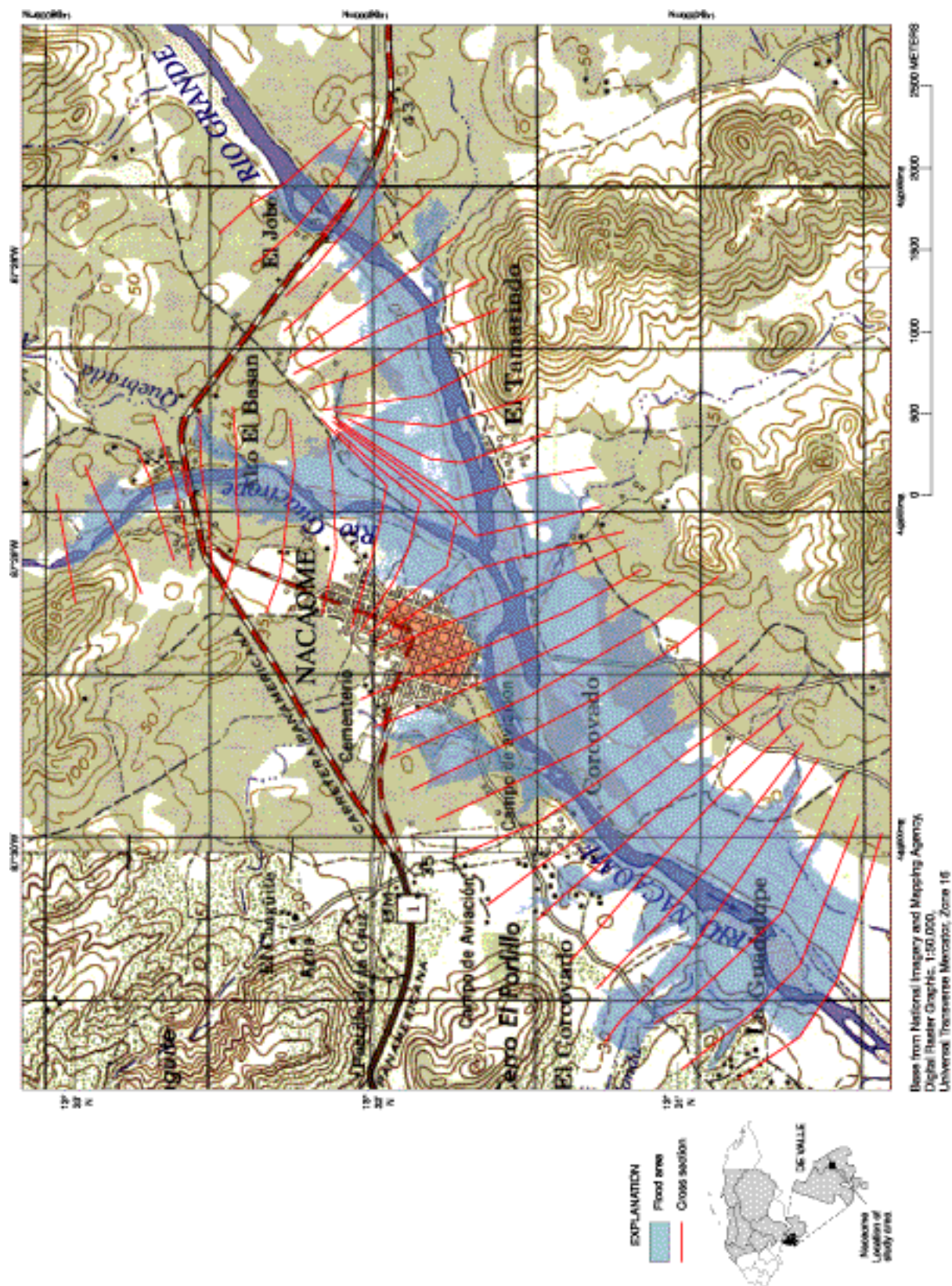
Figure 1. Location of study area and cross sections, and the area of inundation for the 50-year flood on Río Grande, Río Guacirope, and Río Nacaome at Nacaome, Honduras

FIFTY-YEAR FLOOD DISCHARGE

The estimated 50-year-flood discharge of Río Nacaome at Nacaome is the drainage-area adjusted weighted-average of two independently estimated 50-year-flood discharges for the gaging station Río Nacaome en Las Mercedes; one from a frequency analysis of the annual peak-flow discharges at the gage and the other from a regression equation that relates the 50-year-flood discharge to drainage area and mean annual precipitation. The weights used in computing the average were inversely proportional to the variances of the individual estimates. Weighted averages generally provide better estimates of true flood discharges than those determined from either a flood-frequency analysis or a regression equation alone.

The Río Nacaome en Las Mercedes stream-gaging station, which is operated by the Secretaría de Recursos Naturales y Ambiente (SERNA), the national natural resource agency in Honduras, is located about 13 km upstream from Nacaome and has 16 years of annual peak-flow record (table 1). Some maps indicate that the name of the river on which the gaging station is located is Río Grande rather than Río Nacaome. The results of a frequency analysis of the annual peak discharges for the gaging station are shown in table 2 and in an exceedance-probability plot (figure 2). The 1998 annual peak discharge, which resulted from Hurricane Mitch, was estimated to be the highest peak in 100 years. Therefore, a historical adjustment was made to all of the annual peak discharges to account for this (Mastin, 2002).

Table 1. Annual peak discharges at the stream-gaging station Río Nacaome en Las Mercedes, Honduras, for water years 1965–79, 1998

[**Water year**: (May 1 through April 30) is identified by the calendar year in which it begins. For example, the 1957 water year begins on May 1, 1957, and ends on April 30, 1958; **Abbreviations**: m^3/s, cubic meters per second]

Water year	Discharge (m^3/s)	Water year	Discharge (m^3/s)
1965	2,089	1973	1,496
1966	693	1974	3,591
1967	384	1975	904
1968	1,167	1976	404
1969	1,490	1977	695
1970	1,378	1978	610
1971	1,900	1979	1,850
1972	865	1998	[1]9,300

[1]This peak, which resulted from Hurricane Mitch, was estimated to be the highest peak in 100 years (Mastin, 2002).

Table 2. Results of frequency analysis of annual peak flows for the stream-gaging station Río Nacaome en Las Mercedes, Honduras, for water years 1965–79, 1998

[**Abbreviations**: m^3/s, cubic meters per second]

Annual exceedance probability (percent)	Average recurrence interval (years)	Peak flow		
		Estimated value (m^3/s)	95-percent confidence limits	
			Lower (m^3/s)	Upper (m^3/s)
99.5	1.005	242	117	370
99	1.01	276	140	411
95	1.05	400	234	560
90	1.1	492	308	669
80	1.2	638	433	844
50	2	1,079	814	1,424
20	5	1,894	1,435	2,779
10	10	2,579	1,890	4,161
4	25	3,626	2,522	6,597
2	50	4,549	3,039	9,011
1	100	5,601	3,597	12,030
0.5	200	6,801	4,204	15,770
0.2	500	8,646	5,090	22,070
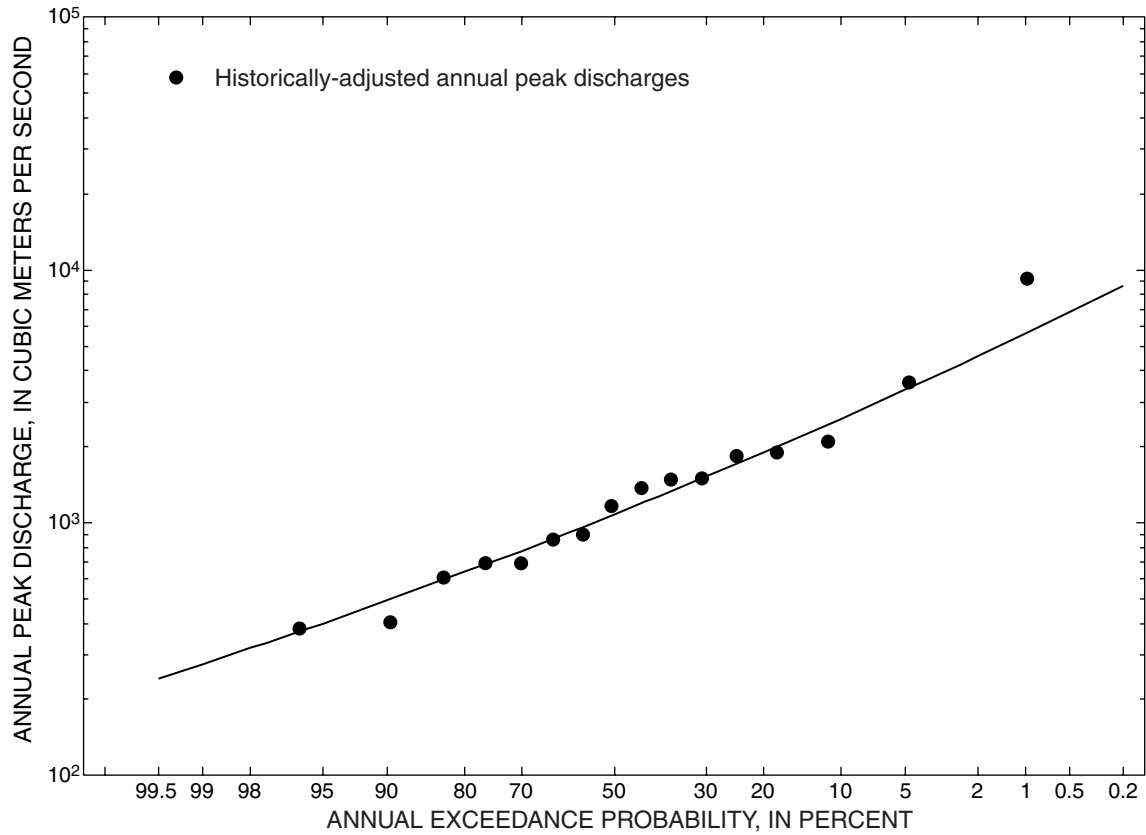
Figure 2. Exceedance probability of annual peak discharge for stream-gaging station Río Nacaome en Las Mercedes, Honduras.

As shown in table 2, the 2-percent exceedance probability (50-year frequency) peak discharge estimated from the gaging station record is 4,549 cubic meters per second (m^3/s).

A regression equation (equation 1) that relates the 50-year peak flow to drainage area and mean annual precipitation was developed using data from 34 streamflow stations throughout Honduras with more than 10 years of annual peak flow record (Mastin, 2002).

$$Q_{50} = 0.0788(DA)^{0.5664}(P)^{0.7693}, \qquad (1)$$

where

Q_{50} is the 50-year-flood discharge, in cubic meters per second (m^3/s),

DA is drainage area, in square kilometers (km^2), and

P is mean annual precipitation over the basin, in mm.

The standard error of estimate of equation 1, which is a measure of the scatter of data about the regression equation, is 0.260 log unit, or 65.6 percent. The standard error of prediction, which is a measure of how well the regression equation predicts the 50-year-flood discharge and includes the scatter of the data about the equation plus the error in the regression equation, equals 0.278 log unit, or 71.3 percent.

The drainage area upstream of the Río Nacaome en Las Mercedes gaging station (1,852 km^2) and of Río Nacaome upstream of Nacaome (2,478 km^2) were computed using a geographic information system (GIS) program to analyze a digital elevation model (DEM) with a 93-meter cell resolution from the National Imagery and Mapping Agency (David Stewart, USGS, written commun., 1999). The mean annual precipitation over the gaging-station basin was calculated to be 1,982 mm using a GIS program to analyze a digitized map of mean annual precipitation at a scale of 1:2,500,000 (Morales-Canales, 1997-1998, p. 15). The 50-year-flood discharge estimated from regression equation 1 for the gaging-station basin was 1,922 m^3/s.

The weighted average of the two estimated 50-year-flood discharges at the Río Nacaome en Las Mercedes gaging station (4,549 m^3/s and 1,922 m^3/s) is 3,770 m^3/s. The 50-year-flood discharge at Nacaome (5,040 m^3/s) was estimated by multiplying the weighted-average discharge at the gage by the ratio of the drainage areas upstream from the two locations.

The 50-year-flood discharges for Río Grande and Río Guacirope were calculated from the weighted 50-year-flood discharge for the Río Nacaome en Las Mercedes gaging station adjusted by the ratios of their drainage areas to the drainage area of the gaged basin. Drainage areas of 1,911 km^2 for Río Grande and 533 km^2 for Río Guacirope were determined using the same GIS coverage used to determine drainage area for Río Nacaome. The estimated 50-year-flood discharges are 3,890 m^3/s for Río Grande and 1,080 m^3/s for Río Guacirope.

WATER-SURFACE PROFILES OF THE 50-YEAR FLOOD

Once a 50-year flood discharge has been estimated, a profile of water-surface elevations along the course of the river can be estimated for the 50-year flood with a step-backwater model, and later used to generate the flood-inundation maps. The U.S. Army Corps of Engineers HEC-RAS modeling system was used for step-backwater modeling. HEC-RAS is a one-dimensional, steady-flow model for computing water-surface profiles in open channels, through bridge openings, and over roads. The basic required inputs to the model are stream discharge, cross sections (geometry) of the river channels and floodplains

perpendicular to the direction of flow, bridge geometry, Manning's roughness coefficients (*n* values) for each cross section, and boundary conditions (U.S. Army Corps of Engineers, 1998).

Cross-section geometry was obtained from a high-resolution DEM created from an airborne LIDAR survey. The LIDAR survey was conducted by personnel from the University of Texas. A fixed-wing aircraft with the LIDAR instrumentation and a precise global positioning system (GPS) flew over the study area on March 3-4, 2000. The relative accuracy of the LIDAR data was determined by comparing LIDAR elevations with GPS ground-surveyed elevations at 312 points in the Nacaome study area. The mean difference between the two sets of elevations is -0.573 meter, and the standard deviation of the differences is 0.068 meter. The LIDAR data were filtered to remove vegetation while retaining the buildings to create a "bare earth" elevation representation of the floodplain. The LIDAR data were processed into a GIS (Arc/Info™) GRID raster coverage of elevations at a 1.5-meter cell resolution. The coverage was then processed into a triangular irregular network (TIN) GIS coverage. Cross sections of elevation data oriented across the floodplain perpendicular to the expected flow direction of the 50-year-flood discharge ([figure 1](#)) were obtained from the TIN using HEC-GeoRAS, a pre- and post-processing GIS program designed for HEC-RAS (U.S. Army Corps of Engineers, 2000). The underwater portions of the cross sections cannot be seen by the LIDAR system. However, because the LIDAR surveys were conducted during a period of extremely low flows, the underwater portions were assumed to be insignificant in comparison with the cross-sectional areas of flow during a 50-year flood; therefore, they were not included in the model.

A reconnaissance visit of the study area was made on October 25, 1999, to determine whether any bridges needed to be surveyed for inclusion in the HEC-RAS model. The only bridge crossing identified for inclusion at that time was the Pan American Highway crossing of Río Guacirope. The bridge geometry of that bridge was surveyed during a field visit on March 16, 2000. Construction of a new bridge at the Pan American Highway crossing of Río Grande was underway at the time of the field visit on March 16, 2000. The geometry of this bridge was surveyed during a field visit on January 10, 2001.

Most hydraulic calculations of flow in channels and overbank areas require an estimate of flow resistance, which is generally expressed as Manning's roughness coefficient, *n*. The effect that roughness coefficients have on water-surface profiles is that as the *n* value is increased, the resistance to flow increases also, which results in higher water-surface elevations. Roughness coefficients (Manning's *n*) for Río Nacaome, Río Grande, and Río Guacirope were estimated from digital photographs taken during the field visit of the study area on October 25, 1999, from field observations and digital photographs taken during field visits on March 16, 2000, and January 10, 2001, and from computer displays of shaded-relief images of the LIDAR-derived DEM before the vegetation removal filter was applied. An *n* value of 0.035 was estimated for the main channels of Río Nacaome, Río Grande, and Río Guacirope, and the *n* values estimated for the floodplain areas ranged from 0.045 to 0.065.

Step-backwater computations require a water-surface elevation as a boundary condition at either the downstream end of the stream reach for flows in the subcritical flow regime or at the upstream end of the reach for flows in the supercritical flow regime. Initial HEC-RAS simulations indicated that the flows in Río Nacaome, Río Grande, and Río Guacirope would be in the subcritical flow regime. Therefore, the boundary condition used was a water-surface elevation at Río Nacaome cross section 0.065, the farthest downstream cross-section in the step-backwater model. This elevation, 23.80 meters, was estimated by a slope-conveyance computation assuming an energy gradient of 0.00125, which was estimated to be equal to the slope of the main-channel bed. The computed water-surface elevations at the first few cross sections upstream may differ from the true elevations if the estimated boundary condition elevation is incorrect. However, if the error in the estimated boundary condition is not large, the computed profile asymptotically approaches the true profile within a few cross sections.

The step-backwater model provided estimates of water-surface elevations at all cross sections for the 50-year-flood discharges (tables 3-5 and figures 3-5). The computed flood elevations near the mouths of Río Grande and Río Guacirope may be a little high because it is unlikely that 50-year floods would occur simultaneously on Río Nacaome, Río Grande, and Río Guacirope.

Table 3. Estimated water-surface elevations for the 50-year-flood on Río Nacaome at Nacaome, Honduras

[Peak flow for the 50-year flood is 5,040 cubic meters per second. **Cross-section stationing**: distance upstream from an arbitrary point near the model boundary; **Minimum channel elevation**, **Water-surface elevation**: elevations are referenced to the World Geodetic System Datum of 1984; **Abbreviations**: km, kilometers; m, meters; m/s, meters per second]

Cross-section stationing (km)	Minimum channel elevation (m)	Average velocity of flow (m/s)	Water-surface elevation (m)
3.626	20.48	3.23	27.63
3.398	20.87	2.96	27.27
3.184	20.90	2.56	27.17
3.000	20.16	2.26	27.08
2.808	19.50	2.39	26.89
2.603	19.10	2.09	26.81
2.366	18.58	1.93	26.68
2.134	17.79	2.51	26.42
1.928	17.50	2.33	26.29
1.722	17.50	2.35	26.16
1.491	17.59	2.81	25.80
1.227	17.58	3.80	24.99
1.011	17.47	3.01	24.94
0.710	15.93	3.27	24.52
0.363	15.64	2.00	24.42
0.065	15.74	3.08	23.80

Table 4. Estimated water-surface elevations for the 50-year-flood on Río Grande at Nacaome, Honduras

[Peak flow for the 50-year flood is 3,890 cubic meters per second. **Cross-section stationing**: distance upstream from confluence with Río Nacaome; **Minimum channel elevation**, **Water-surface elevation**: elevations are referenced to the World Geodetic System Datum of 1984; **Abbreviations**: km, kilometers; m, meters; m/s, meters per second]

Cross-section stationing (km)	Minimum channel elevation (m)	Average velocity of flow (m/s)	Water-surface elevation (m)
2.699	24.35	2.95	31.65
2.479	22.94	1.95	31.63
2.332	23.05	3.44	31.10
2.324 (bridge)			
2.300	23.05	3.57	30.85
2.228	22.91	3.02	30.89
2.042	23.06	2.89	30.76
1.795	23.11	2.90	30.56
1.569	22.95	2.52	30.46
1.398	23.01	3.04	30.06
1.081	23.12	3.71	29.31
0.857	23.07	3.34	29.02
0.604	23.01	3.21	28.61
0.391	22.95	2.84	28.39
0.132	20.81	2.63	28.15

Table 5. Estimated water-surface elevations for the 50-year-flood on Río Guacirope at Nacaome, Honduras

[Peak flow for the 50-year flood is 1,080 cubic meters per second. **Cross-section stationing**: distance upstream from confluence with Río Nacaome; **Minimum channel elevation**, **Water-surface elevation**: elevations are referenced to the World Geodetic System Datum of 1984; **Abbreviations**: km, kilometers; m, meters; m/s, meters per second]

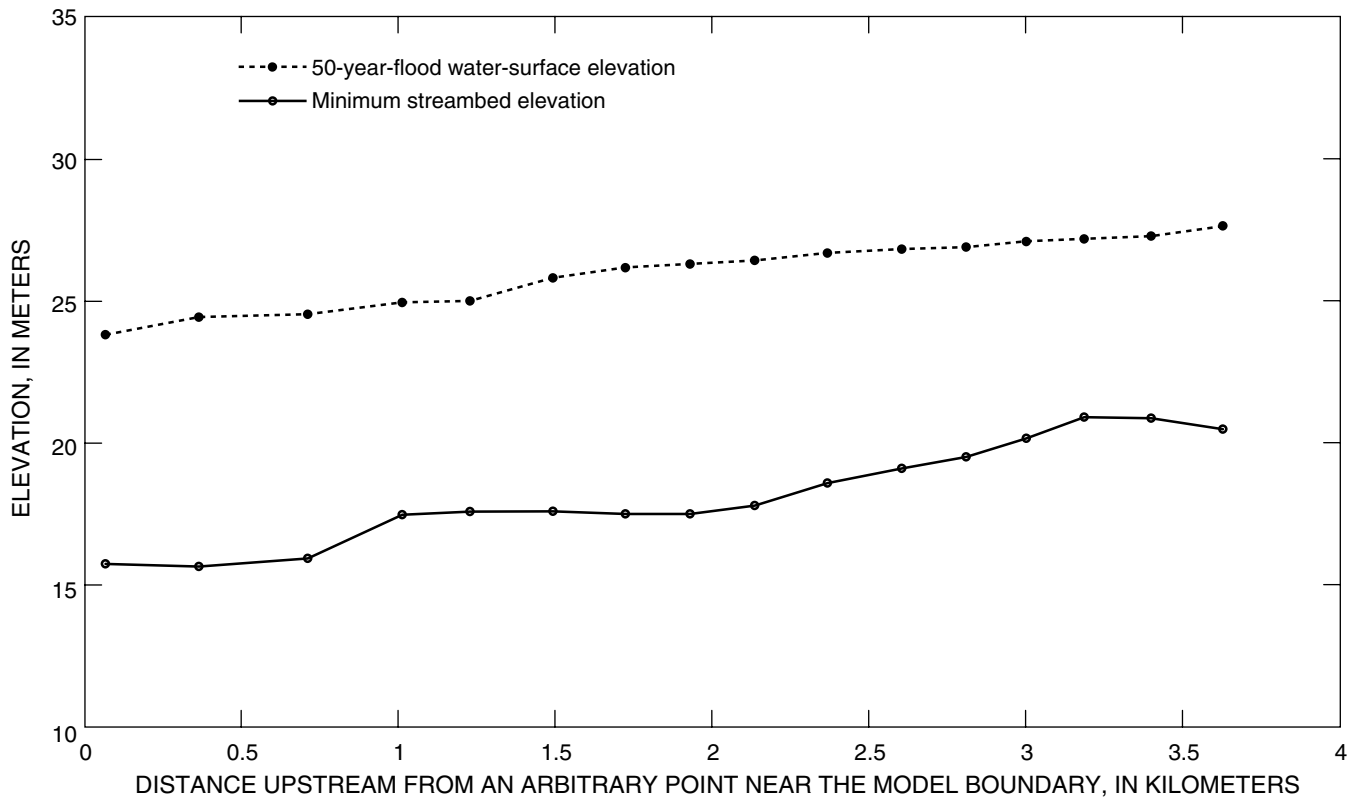| Cross-section stationing (km)	Minimum channel elevation (m)	Average velocity of flow (m/s)	Water-surface elevation (m)
2.934	26.11	2.85	31.18
2.600	25.49	2.51	30.73
2.280	24.83	2.90	30.15
2.134	24.79	2.41	30.03
2.062	24.92	2.06	30.05
2.060 (bridge)			
2.050	24.92	2.07	30.03
1.959	24.83	2.69	29.70
1.750	24.54	2.04	29.53
1.360	22.65	1.78	29.28
1.073	22.09	1.55	29.16
0.779	21.73	2.30	28.77
0.565	21.65	2.34	28.65
0.314	21.42	2.16	28.52

Figure 3. Water-surface profile, estimated using the step-backwater model HEC-RAS, for the 50-year flood on Río Nacaome at Nacaome, Honduras.
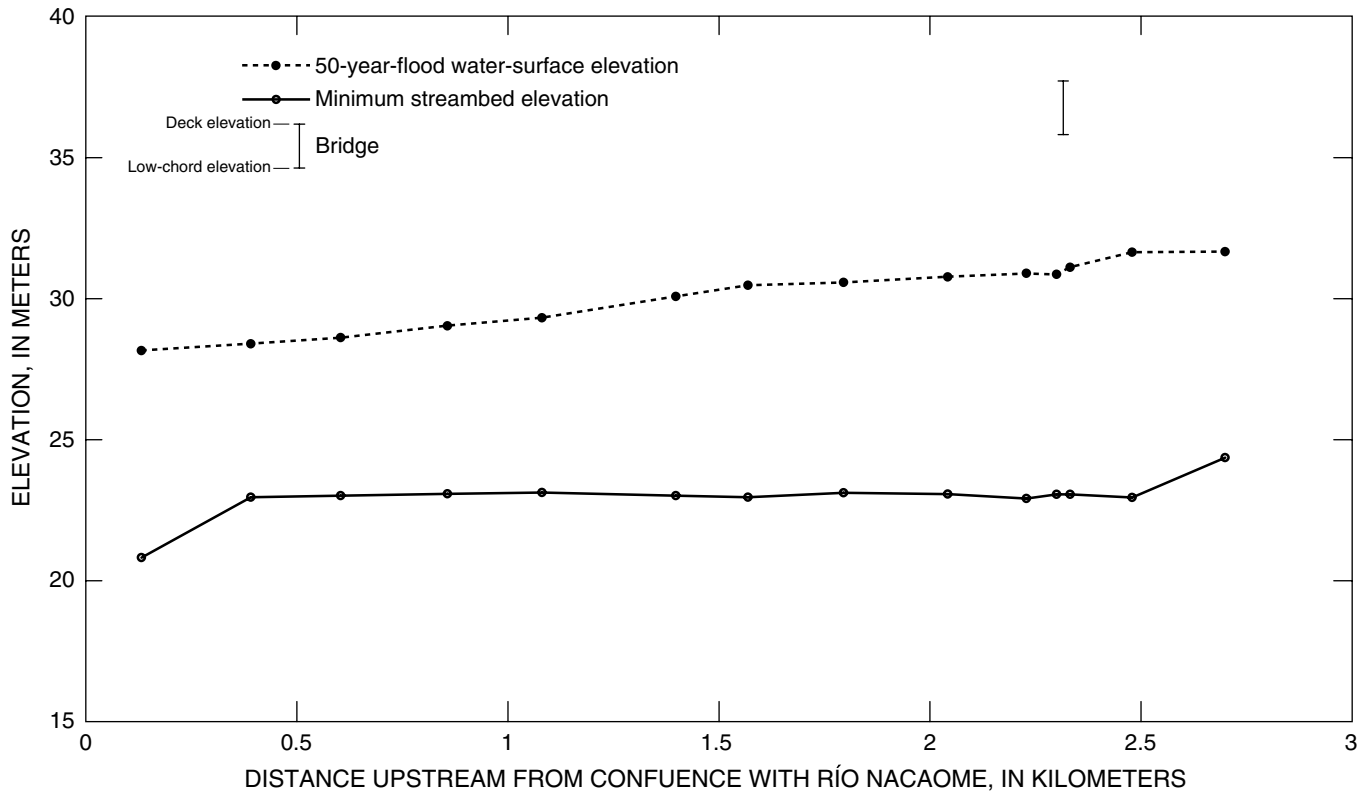
Figure 4. Water-surface profile, estimated using the step-backwater model HEC-RAS, for the 50-year flood on Río Grande at Nacaome, Honduras.
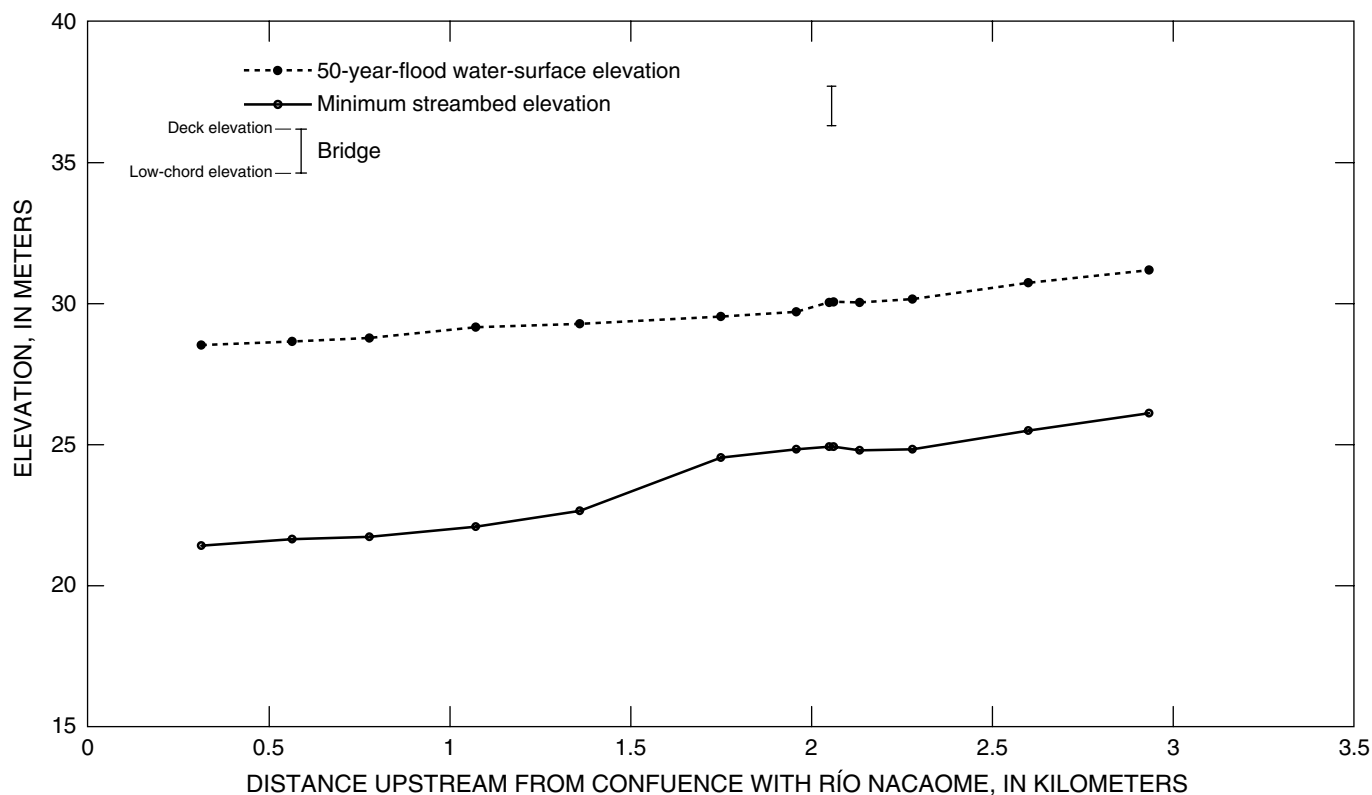
Figure 5. Water-surface profile, estimated using the step-backwater model HEC-RAS, for the 50-year flood on Río Guacirope at Nacaome, Honduras.

FIFTY-YEAR FLOOD-INUNDATION MAPS

The results from the step-backwater hydraulic model were processed by the computer program HEC-GeoRAS to create GIS coverages of the area and depth of inundation for the study area. The GIS coverage of area of inundation was created by intersecting the computed water-surface elevations with the topographic TIN that was produced from the LIDAR data. This coverage was then overlain on an existing 1:50,000 topographic digital raster graphics map (figure 1) produced by the U.S. National Imagery and Mapping Agency (Gary Fairgrieve, USGS, written commun., 1999). Depth of inundation at Nacaome for 50-year-floods on Río Nacaome, Río Grande, and Río Guacirope (figure 6) was computed by subtracting the topographic TIN from a computed water-surface elevation TIN to produce a grid with a cell size of 2 meters.

The area of inundation includes floodplain areas along most of the study-area reaches including areas on the shoreward side of flood-control levees. Although water-surface elevations along the approximately 400-meter-long levee on the right-bank floodplain (looking downstream) between Río Nacaome cross-sections 3.398 and 3.626 are about 1 meter below the top of the levee, low-lying areas behind the levee would be inundated by floodwaters going around the ends of the levee or through two apparent openings in the levee. Water-surface elevations are at or slightly above the top of most of the length of the approximately 630-meter-long levee on the left-bank floodplain between Río Grande cross-section 0.391 and Río Nacaome cross-section 3.398. Therefore, the low-lying areas behind this levee would be inundated by a combination of the overtopping of the levee and floodwaters going around the downstream end of the levee.

Figure 6. Depth of inundation for the 50-year flood and location of cross sections on Río Grande, Río Guacirope, and Río Nacaome at Nacaome, Honduras.

Also, low-lying areas behind the approximately 1,060-meter-long levee along the left-bank floodplain of Río Nacaome between cross-sections 1.722 and 0.710 would be inundated by floodwaters flowing around the upstream end of the levee. At this location the floodplain is inundated for a distance of more than 500 meters shoreward from the levee.

Although the Pan American Highway bridge crossing of Río Grande has very little effect on water-surface elevations, a short section of the Highway about 200 meters southeast of Río Grande would be inundated to a depth of about 1 meter as a result of backwater entering a small unnamed Río Grande tributary.

The flood-hazard maps are intended to provide a basic tool for planning or for engineering projects in or near the Río Nacaome, Río Grande, and Río Guacirope floodplains. This tool can reasonably separate high-hazard from low-hazard areas in the floodplain to minimize future flood losses. However, significant introduced or natural changes in main-channel or floodplain geometry or location can affect the area and depth of inundation. Also, encroachment into the floodplain with structures or fill will reduce flood-carrying capacity and thereby increase the potential height of floodwaters, and may also increase the area of inundation.

DATA AVAILABILITY

GIS coverages of flood inundation and flood depths shown on the maps in figures 1 and 6 are available in the Municipal GIS project, a concurrent USAID-sponsored USGS project that will integrate maps, orthorectified aerial photography, and other available natural resource data for a particular municipality into a common geographic database. The GIS project, which is located on a computer in the Nacaome municipality office, allows users to view the GIS coverages in much more detail than shown on figures 1 and 6. The GIS project will also allow users to overlay other GIS coverages over the inundation and flood-depth boundaries to further facilitate planning and engineering. Additional information about the Municipal GIS project is available on the Internet at the GIS Products Web page (http://mitchnts1.cr.usgs.gov/projects/gis.html), a part of the USGS Hurricane Mitch Program Web site.

The GIS coverages and the HEC-RAS model files for this study are available on the Internet at the Flood Hazard Mapping Web page (http://mitchnts1.cr.usgs.gov/projects/floodhazard.html), which is also a part of the USGS Hurricane Mitch Program Web site.

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